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## DISCUSSION

DEXTER S. KIMBALL, Cornell University: I have read Professor Hayford's paper with both pleasure and profit, and I find myself agreeing, in general, with his point of view. It is certainly true that engineering and economics are very closely connected—more closely than most people are aware, though this connection is almost obvious.

Every civilization must rest upon some kind of industrial foundation, and the industrial background fixes absolutely the height to which the civilization built upon it may rise. The older civilizations were founded on handicraft and primitive industrial methods. In any civilization resting upon such an industrial basis the many must work without the bodily comforts of life, to say nothing of mental development, in order that the few may enjoy the earth. We have undertaken in this more enlightened age to build a civilization in which all may have physical comforts and mental development. This attainment is possible, so far as we can see, only by the use of the modern industrial methods which in a broad way we call engineering.

Now, engineering has to do with the *productive* side of industry. It is concerned with ways and means of conquering nature. But we have found that the industrial mechanism necessary for our purposes cannot be operated without affecting our *social* and *political* organization. We have found that it is not possible to separate *production* from *distribution*. Obviously the engineer must study the economics of distribution and the economist must also be a deep student of industry. If an industrial prophet shall arise, an economic Moses who shall lead us out of the wilderness in which we now blindly wander, I am confident that he will be an engineer-economist or an economist-engineer, it matters not which.

The engineer is an economist by nature and training. Efficiency and economy are matters that are ever before him. They are involved in the design of every machine, every industrial plant, that he produces. The design of a great power-station, for instance, is a most interesting economic problem. No less is a great terminal or a steamship. All involve economic consideration as truly as does a discussion of railroad rates or of the tariff. The engineer is therefore familiar with economic methods of thought, and has, perhaps, developed greater accuracy in this line than has any other worker. But, again, the economics used by the engineer are, for the most part, those of the science of production. The criticism made by Professor Hayford that the engineer is lacking in knowledge of the broader field of the economics of distribution is therefore well taken.

This defect has been discovered both by the engineer and by those employing him. Some years ago employers, especially those interested in large industrial undertakings, found that educated engineers were desirable employees, not only because of their technical knowledge, but because they were very valuable also on the business side of the undertaking, when their

technical education had been supplemented by a broader understanding of the business principles involved. And this, it will be noted, was not because of the engineer's actual technical knowledge so much as because of the *methods* which his technical training had developed in him. The habit of thinking clearly and accurately regarding complex conditions is the greatest asset that technical education can bestow on a young man. This same quality is just as essential in business and explains why young technical graduates are finding such an opportunity in fields more or less remotely connected with technical engineering. Industry, furthermore, is such a dominating factor in our national life that business of any kind cannot escape close contact with engineering of some kind.

Industrial changes are reflected quickly in the courses of instruction of live colleges and universities. It is not surprising, therefore, to find elementary economics, the basis of all discussions regarding distribution of wealth, rapidly becoming a requirement for technical degrees. Technical schools have had a difficult problem for many years in providing simply for technical requirements, but many of the leading technical schools have made provision for some study of economics. At Cornell University elementary economics has been a requirement for all engineers for some years and there has been a decided change in the attitude of our students toward these studies since they were made requirements. All who have taught in technical schools have experienced the reluctance, sometimes amounting to obstinacy, on the part of technical students in the matter of taking other lines of work outside their specialty, as a requirement for the degree, unless these lines of work seem to bear directly upon their specialty. In the beginning we experienced all of these difficulties, but have overcome them. Elementary economics is a required subject in all Senior options in mechanical and electrical engineering excepting the industrial engineering option. For this latter option elementary economics must be taken prior to the Senior year and taken, therefore, in addition to a very heavy schedule of technical studies. In spite of this extra requirement the industrial option, which contains other economic studies in the Senior year, has a larger enrolment this year than any other of the six options, 51 out of the total of 190 Seniors in mechanical engineering electing this group of studies which look toward the broader problems of industry. Eighty-eight men in other groups have also passed the elementary economics, indicating that there is a strong sentiment among students that this line of work is an integral part of the preparation for life and that they are anxious to obtain advanced work of this kind in their Senior year.

I do not find myself in full accord with Professor Hayford's statement that the mistakes of engineers are frequently due to lack of this broader vision. Of course, engineers make mistakes; so do doctors (though no one finds them out), so do lawyers, financiers, and even economists. But I do not believe that the engineer's mistakes, such as Professor Hayford has mentioned, are due so much to his lack of knowledge as to the circumstances under

which he has always worked. It should be borne in mind that all industry at present is promoted largely from selfish viewpoints. This must be so under any competitive system. The engineer, for the most part, has been an employee, a hired man, paid to work out the economics of the productive side of the enterprise without regard to the broader view. Where, indeed, do we find men conducting private industry with this broader view in mind? Even when the engineer has been called upon to report on enterprises that involved the welfare of a large community, he has generally found limitations imposed upon his activities. Does anyone suppose, for instance, that an adverse report by a group of able engineers on the enlargement of the Erie Canal would have prohibited the enterprise, though their arguments were based on the broadest economic theory? Yet there is a reasonable doubt, even in the minds of laymen, regarding the economic soundness of this work. Will any broad economic arguments advanced by engineers stop avaricious capital from running a competing railroad and ruining a competitor if possible? Such a contingency is hardly probable, and the engineer should not be blamed for defects that are inherent in our industrial organization. These things will cease to be only when we have developed a higher social consciousness than we now possess. What form of co-operative effort this consciousness will take is not clear, but it is the one great problem of our industrial life. I believe, as I have already stated, that the engineer is destined to play an important part in the solution of this problem, and this is the greatest reason, I believe, for insisting that the engineer be given the broader economic vision. I do not think it fair, however, to single out the engineer for blame in these matters for which we are all more or less responsible and which are often so very complex.

Like Professor Hayford, I do not believe in special courses of economics for engineers; no more do I believe that there are such things as "engineering English" and "engineering mathematics." There is, of course, a great art in selecting the content of any course of instruction; but there is far more in the manner in which this content is presented. Elementary courses of any kind are the most difficult to make interesting and fruitful, and the teacher who can so present them is an artist. Such elementary courses, be they chemistry, physics, or economics, should not, therefore, be turned over to inferior teachers, but should be in the hands of the older and abler members of the staff. Unfortunately, the tendency in large American universities is away from this ideal, but I am firmly convinced that ere long we shall see the error of this movement and insist that all men teaching the elementary work shall be the best obtainable. This is particularly important in the case of economics, where such studies are given to technical men in their Junior or Senior year, when their minds already have been developed somewhat and where they have already been brought into contact with strong teachers in other lines. Instruction in economics to men of this kind must be clear and virile to engage their interested attention.

In conclusion, I should like to emphasize the remarks of Professor Hayford as to the broadening effects of economic studies. I am a firm believer in the value of classical studies so far as they apply to educational problems. But they are not sufficient of themselves for modern life and modern problems, and a new industrial era demands new and broader preparation for life. Our new problems in social and political organization have no counterpart in history and differ radically from anything contemplated in the old humanities and classical studies. They are in fact *new humanities*, and who shall say they are not as important as any that have gone before? Is the study of the tremendous changes now taking place in our social and political fabric, with its complex components of socialism, single tax, equal suffrage, universal education, industrial legislation and regulation, compulsory sanitation, and the great economic considerations resulting therefrom, less important to humanity physically, morally, and mentally than a study of ancient forms and dogmas that have no bearing on present-day existence? Most certainly they are not if our standard is the things that uplift mankind mentally and spiritually. These are things that are of vital interest to all men and the study of which is truly liberalizing. They are real humanities; and the older humanities and classical studies will survive only as they can be interpreted to assist in these new problems or inspire men to higher planes of thought and action. By all means let all engineers study economics and let all economists study industry, for therein lies our hope.

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LLOYD M. CROSGRAVE, University of Minnesota: There are, it seems to me, two chief contentions in Professor Hayford's paper. One is that an engineer will do better professional work if he understands the ultimate social consequences of his work. The other is that an engineering student should be furnished the same kind of course in economics as is furnished the academic student.

If I have correctly stated the two chief contentions, then I disagree with both of them. I do not believe, in the first place, that the average individual carries on his daily work in order to help society—a man may sometimes vote to that end but he does not carry on his business for that purpose; and I do not believe, in the second place, that a student of engineering who can study economics for only one year should be given the same course as the student who intends to make economics his major subject.

To my mind, the engineer should, in the first place, be given that economic instruction that will put him into proper relationship with his future employer, and this means that he should be acquainted with the problems of corporation organization, corporation finance, municipal ownership, and allied matters, because the engineer will almost certainly be employed by an industrial corporation or by a municipality. In the second place, the engineer should

be taught how to be an intelligent superintendent of labor, because work of this nature is likely to fall to his lot. In the third place, and finally, the engineer should be aided in his efforts to arrive at sound conclusions on public questions, in order that he may vote properly and be a useful leader in his community.

To my mind the traditional introductory course—the “Elements of Economics”—is very poorly adapted to meet these needs of engineering students. The course omits much that they should be taught; it includes much that is useless to them; it is not correct pedagogically, because it begins with the general and goes from this to the particular; and finally, it fails to arouse the interest and enthusiasm of the students. A new course, especially designed for engineers, should be developed. Experiments in this direction at the University of Minnesota seem to be very successful.